Seattle Public Utilities

Protecting Seattle's Waterways

Integrated Plan

Stormwater Project Selection Process for Further Consideration

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SECTION 1

Introduction

This document provides an overview of the process and methods that Seattle Public Utilities (SPU) used to identify stormwater projects for evaluation as part of the planning effort known as the Integrated Plan. Section 2 describes the process used to select stormwater projects. Section 3 provides an overview of the stormwater projects that were selected for evaluation. Sections 4 thru 7 provide information on criteria that were used to help determine if there were any “fatal flaws” with the stormwater projects. The fatal flaws analysis served as a first screen to help the SPU team identify possible stormwater projects that could meet the objectives of the Integrated Plan. Additional screening, Multi Objective Decision Analysis (MODA) and other tools, will be used to further refine the list of candidate stormwater projects for inclusion in the Integrated Plan.

SECTION 2

Stormwater Projects Selection Process

This section provides a high level overview of the stormwater treatment project evaluation and screening process that was used to develop the list of stormwater projects for consideration in the Integrated Plan. The process was a broad approach for identifying potential best management practices (BMPs) that have significant merit for further analysis and potential inclusion in the Integrated Plan. Additional evaluation in the future development of each project or in the Integrated Plan could affect the recommendations in various ways:

- Further detailed investigation of individual basins or projects may indicate new alternatives that need to be investigated.
- Currently unknown collaborative projects with other departments or agencies may be identified.
- Community involvement and environmental review process may influence selection of preferred projects.
- The implementation process will involve a thorough benefit/cost analysis that includes an awareness of locations of sensitive areas and appropriate prioritization for project implementation.
- Implementation needs to be an iterative process as information is further developed and other non-cost factors are integrated into the recommended alternatives.

2.1 Alternative Evaluation Process

The following steps were used by the Integrated Planning Team members to develop a list of stormwater treatment projects for each priority basin:

- **Step 2.1** — Identify characteristics of the priority ranked basins.
- **Step 2.2** — Identify receiving water body and its primary pollutant(s) of concern.
- **Step 2.3** — Develop Pollutant and Flow Estimates for each basin
- **Step 2.4** — Use the GIS basin atlas information and knowledge of stormwater treatment technologies to identify potential locations for stormwater treatment considering the general (Section 4) and project fatal flaw screening criteria (Sections 5-7)
- **Step 2.5** — Develop planning-level cost estimates for each of the stormwater treatment alternatives.
- **Step 2.6** —Based upon cost-effectiveness, rank the stormwater projects and determine which projects to include in the list for further development in Integrated Plan.

Step 2.1— Basin Characteristics

Geographic Information Systems (GIS) data was used to create a Basin Atlas for each of the basins identified by the SPU Integrated Plan team as a high priority basin. (For more information, see the description of the basin ranking process in the Integrated Plan Briefing Memorandum for the April 29, 2013, Expert Panel meeting.) These GIS data were displayed in a series of maps to provide basin characteristics to the team charged with identification of potential stormwater projects. Information included in the atlas included:

- Aerial Overview
- Surface Type, i.e. impervious or pervious and the percentage of the basin that discharges to CSO vs. the stormwater system.
- Land Use and Zoning
- Existing/Proposed Water Quality Treatment
- Underground Facility Opportunities/Constraints
- Partnership Opportunities
- Location Opportunities for Retrofit
- Green Stormwater Infrastructure Suitability
- Source Control and Monitoring
- Topography

Using the GIS data the SPU Integrated Plan team conducted a quick evaluation of the high priority basins to identify potential locations to install stormwater projects. Once the location(s) were identified, the team used their knowledge of stormwater treatment, and receiving water body pollutants of concern, Step 2.2, to identify a stormwater project(s) for the basin.

Step 2.2—Receiving Water Body Pollutants of Concern

The pollutants of concern for each receiving water body were established for the Integrated Plan by the SPU Water Quality team based on consideration of the Consent Decree, TMDL listings or impairments, available water quality data, and best professional judgment. The pollutants were rated on a high-moderate-low scale with each rating defined as follows:

- High (⬤) rating: High is given to the pollutant considered the target pollutant of concern for the stormwater treatment BMPs. This is the pollutant directly related to the TMDL listings or impairments, available water quality data, or best professional judgment. While the target pollutant is the focus for the BMP, much of the time, addressing the primary POC will also reduce many of the medium and low rated pollutants.

- Moderate (⬤) rating: Moderate is given to a pollutant that treatment is recommended in addition to the target pollutant being addressed by the stormwater treatment BMP. These pollutants are present in the stormwater from the basin, and may be impacting the receiving water body; however, they are not the most critical pollutant to address in the basin.

- Low (⬤) rating: Low is given to a pollutant that treatment should be considered in addition to the target pollutant being treated by the stormwater treatment BMP, but it is not necessary for the pollutant removal to be planned for, or used in the sizing of facilities.

- Not applicable (⬤): NA is given to a pollutant that has no known measurable impact on the receiving water body.

Total Suspended Solids (TSS) was used as the surrogate for pollutants that tend to adsorb and those that are in particulate form. These pollutants include many of the organics and particulate metals.

Step 2.3 — Develop Pollutant and Flow Estimates for each Basin

The next step in the process was to develop TSS and flow estimates for each basin. Basins receiving a high priority ranking were assessed, identifying physical characteristics (impervious area, land use, etc.), hydraulic flow rates (water quality flows using Western Washington Hydrologic Model (V3) (WWHM3)), and the TSS load contributed from the basin to the receiving water body.

The TSS load for each of the basins was estimated using the GIS Pollutant Load Estimator Tool (PLT) developed by SPU. The PLT tool estimates average annual runoff volumes (AARV) and TSS loads based on the 25th, 50th (median) and 75th percentile concentrations. Runoff calculations and TSS input are broken down into categories based on land use/zoning and surface cover conditions.

Average Annual Runoff Volume (AARV) is estimated using the Simple Method.[1] The median TSS concentration is used to estimate average annual TSS loads for each basin. The TSS values used in the PLT are based upon data obtained from the Pitt et al 2005a report, *Sources of Pollutants in Urban Areas.*[2] Additional information on the PLT can be found in the SPU Standard Operating Procedures WQE 1100 and WQE 1200.

The average annual runoff volumes and TSS loads were used by the SPU team to estimate the TSS load removed per year in kilograms for each of the stormwater projects.

The WWHM3 model was used to estimate the flow volume, the online flow and offline flow for the basin or the area of the basin that the stormwater project serves. These data were used to size the facility, which fed into Step 2.4 where the stormwater project(s) was selected and Step 2.5 where a cost estimate was generated.

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[1] Stormwater Center (2006). The Simple Method to Calculate Urban Stormwater Loads. http://www.stormwatercenter.net/monitoring%20and%20assessment/simple%20meth/simple.htm.

[2] Pitt et al 2005a. TSS concentration by land use and surface type, APPENDIX A: Sources of Pollutants in Urban Areas, Table 24.2. Data from Pitt, Bannerman, Clark and Williamson. 2005. Sources of pollutant in urban areas, Part 2. pp. 485-530 in: Effective modeling or urban stormwater systems, Monograph 13. W. James, K. N. Irvine, E. A. McBean, and R.E. Pitt (editors). CHI, Ontario, CA. 2005

Step 2.4 – BMP Feasibility Screening

Utilizing the pollutants of concern for each receiving water body (Step 2.2); the basin specific attributes from the GIS Basin Atlas; and the pollutant and flow estimates for each Basin (Step 2.3), a subset of prioritized BMPs were identified for each high priority drainage basin. These BMPs were then developed into concept-level stormwater treatment designs.

Step 2.5 – Cost Estimating

As part of the CSO Long Term Control Plan (LTCP) project, a cost estimating tool was developed using the line item costs from bid tabs, schedule of values and estimates for completed projects and projects in construction. The tool included methods for estimating pipelines (open cut and trenchless technologies), storage facilities, and pump stations.

To prepare cost estimates for the alternative analysis for the Integrated Plan, the LTCP cost tool was updated to include three additional construction features: Dry/wet ponds, regional water quality treatment facilities, and green stormwater infrastructure (GSI) or natural drainage solutions (NDS). Along with the additional construction features, the following assumptions were generally used to develop individual project estimates:

The accuracy of the estimates is assumed to be Association for the Advancement of Cost Engineering (AACE) Class 5 (+50 to -30%). A Class 5 estimate is the highest level of estimate and most applicable for conceptual design stage (0% - 2% design level) screening and feasibility.

The cost estimating approach is consistent with SPU’s Cost Estimating Guide including estimates for soft costs and allowances for contingencies.

2.6 Stormwater Project Ranking

Following completion of the concept-level stormwater treatment designs a quality control check was conducted to verify that all of the designs contained the required information (pollutant and flow estimations, cost estimation). After completion of the quality control check the projects were ranked based upon their efficiency, which is the unit cost represented by Life-Cycle $/kg TSS per year. For the purposes of ranking the projects at this stage, the higher the efficiency, represented by low life-cycle cots per kg TSS per year, the higher the rank of the project. The ranked projects are displayed in Table 1. Please note that this was the initial rank of the projects and the ranking may change due to the pollutant reduction estimations and rating and ranking using Multi Objective Decision Analysis (MODA).

SECTION 3

Recommended Stormwater Alternatives

A list of potential stormwater treatment projects are presented for each basin in Table 1. Projects are designed to concept-level because of the planning-level nature of this document, a cost range of + 50% to – 30% is also presented for basins to conform with Level 5 estimating criteria established by the AACE. The intent is to provide a relative ranking of the list of stormwater BMPs that may provide significant water quality benefits.

TSS was used as the indicator pollutant. This is deemed appropriate as the majority of the stormwater technologies available provide basic treatment, which has a performance standard based on TSS removal. Further analyses during the Integrated Plan development will consider other constituents, including metals (dissolved and total), nutrients, BOD, and organic compounds.

The annual pollutant load reduction is a function of the influent concentration, the AARV treated and/or lost (infiltration), and the technology removal efficiency. The influent concentration is estimated using land use runoff quality information and the technology removal efficiency is estimated from available performance studies, such as Ecology's Technology Assessment Program (TAP), vendor information, King County and City pilot studies of treatment technologies, and other studies reported in the literature (e.g., International BMP data base and local studies). Pollutant removal efficiencies for each technology were applied to the estimated annual TSS load for the portion of flow expected to be treated (based on City Stormwater Code and design manual), to calculate the overall reduction in loading

For water quality facilities, the AARV is typically estimated either from WWHM3, using a long-term precipitation record (the 158-year 5-minute synthetic data series or the 50-year SeaTac data series), or by the Simple Method. For Natural Drainage Systems (NDS) facilities, the AARV is estimated using a ratio of 2.1 acre-feet AARV per impervious acre treated, developed using WWHM3 and the 25-year 5-minute precipitation series from SPU Rain Gage 3 (RG03) which is located at the University of Washington in Seattle. The RG03 average annual precipitation is less than used when sizing water quality facilities (30.7, 37.9, 37.2 inches for RG03, synthetic series, and Simple method, respectively. For NDS projects, the sizing tables from the Volume 3 of the City of Seattle's Directors' Rules[3]

[3] Directors' Rules: 2009-005 SPU/17-2009 DPD available at: http://www.seattle.gov/dpd/Codes/StormwaterCode/Codes/default.asp

were used to size the facilities rather than WWHM3. For TSS pollutant reduction estimates, the GSI projects were given credit for treating 91% of the sizing volume, rather than 91% of the basin AARV. The TSS pollutant reduction estimates for the conventional stormwater projects used 91% of the basin AARV.

Unit costs for peak/duration control and volume reduction were estimated using similar methodology for pollutant load reduction, which differs from the CSO program (e.g., life-cycle cost over present value of the benefit).

Life-cycle costs do not consistently include the expected commissioning date, which may bias the unit costs slightly. Summary unit costs (life-cycle $/kg TSS removed per year) are estimated using a weighted average.

The stormwater BMPs are ranked and grouped into four groups based upon the following criteria (displayed in Figure 1 and listed in Table 1 by priority rank):

- Group 1 alternatives provide an estimated high pollutant load reduction performance (kg TSS/year) at a low unit cost (life cycle $/$kg TSS per year).
- Group 2 alternatives provide an estimated high pollutant load reduction performance (kg TSS/year) at a high unit cost (life cycle $/$kg TSS per year).
- Group 3 alternatives provide an estimated low pollutant load reduction performance (kg TSS/year) at a low unit cost (life cycle $/$kg TSS per year).
- Group 4 alternatives provide an estimated low pollutant load reduction performance (kg TSS/year) at a high unit cost (life cycle $/$kg TSS per year).

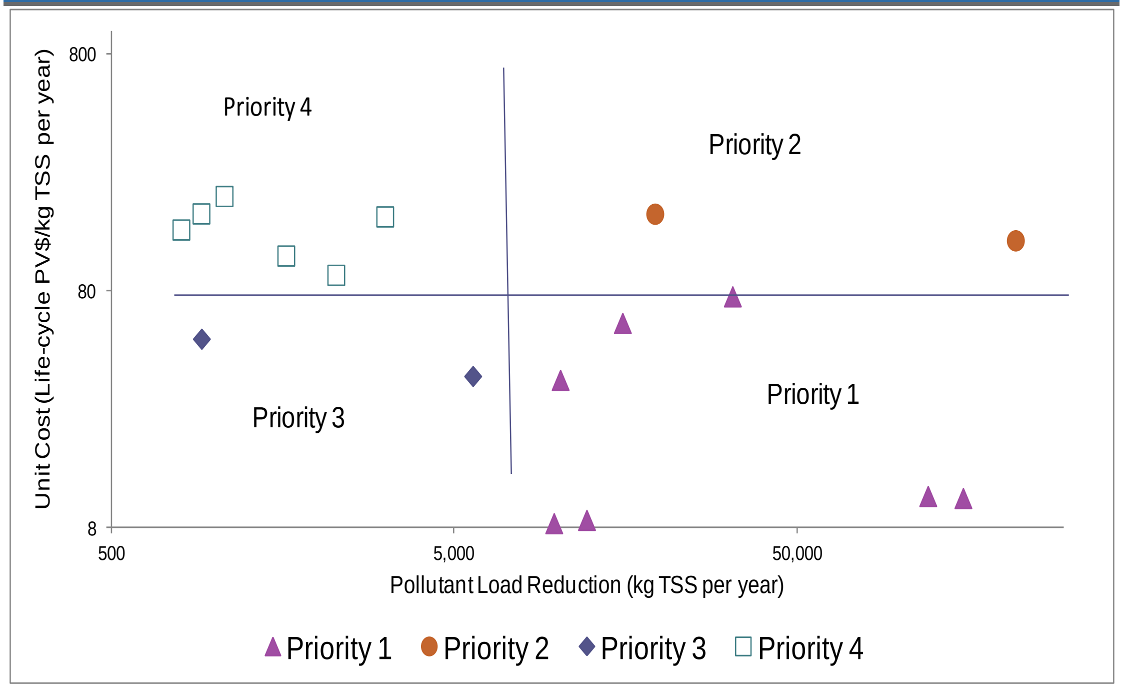

Figure 1 *Stormwater Project Grouping*

Table 1 – *Priority Ranked Stormwater Projects*

Priority		Stormwater Project Description	Performance	Efficiency	Resource Needs	
Group	*Rank*[4]	*Project*	*Pollutant Load (kg/TSS/year)*	*Unit Cost (Life-Cycle $/kg TSS per year)*	*Capital ($M)*	*O&M ($k/year)*
1	1	Street Sweeping Expansion/Phase II	150,000	$11	$3.0	$1,500
	2	Street Sweeping Expansion/Phase I	120,000	$11	$2.0	$1,200
	3	South Park WQ Facility/Active Trtmnt, basic	32,000	$76	$26	$460
	4	Minor Ave/I-5 StormFilter Vault	15,000	$59	$15	$250
	5	Webster Pond/Pretreatment	12,000	$9	$2.4	$1.2
	6	Blue Dog Pond/Pretreatment	10,000	$8	$2.0	$1.2
2	7	Joint Wet Weather Treatment/All basins	220,000	$130	$380	$2,900
	8	NDS Partnering/Pipers, Longfellow, Thornton	19,000	$170	$59	$270
3	9	SW Hinds SD/StormFilter Vault	5,600	$35	$3.7	$140
	10	South Myrtle/Shoulder Stabilization	910	$50	$0.5	$9
4	11	Piper's/Bioretention Flow Routing	3,100	$170	$11	$38
	12	Longfellow/Bioretention Flow Routing	2,200	$94	$4	$19
	13	South Myrtle SD/StormFilter Vault	1,600	$110	$1.6	$89
	14	Minor Ave/Cascade Filterras (14-4x4)	1,100	$200	$4.5	$5
	15	U Village/Filterras (13-4x4, 13-4x8)	910	$170	$3.4	$9.2

[4] Note that this is an initial ranking and that ranking of projects may change with further analysis.

3.1 Brief Description of Recommended Stormwater BMP Alternatives

The follow are brief descriptions of the concept level BMPs in ranked order that will be considered for development of the Integrated Plan.

1. Street Sweeping Expansion/Phase II– The Street Sweeping for Water Quality (SS4WQ) program currently conducts sweeping using high efficiency regenerative air sweepers on curbed arterial streets in areas that discharge to the municipal separate storm sewer system. This project proposes to expand the program into residential areas to sweep up to 650 lane miles bi-weekly during the day over a 46-week period (an increase of 68% of curbed local streets). Sweeping would occur throughout the drainage system discharging to all major receiving water bodies.
2. Street Sweeping Expansion/Phase I - The SS4WQ program currently conducts sweeping using high efficiency regenerative air sweepers on curbed arterial streets in areas that discharge to the municipal separate storm sewer system. This project proposes to expand the program to additional arterial streets to increase bi-weekly sweeping from 78% of the arterials to 83% to 85% of the arterials over a 40 to 48-week period. Sweeping would occur throughout the drainage system discharging to all major receiving water bodies.
3. South Park WQ Facility/Active Trtmnt, Basic – This proposed project is a basic, active treatment facility (e.g., chitosan-enhanced sand filtration system) that treats stormwater from the 232-acre 7th Ave S drainage basin prior to discharge into the Duwamish Waterway. Land use in the drainage basin consists of primarily industrial (33 percent), residential (25 percent), right of way (18 percent) with small amounts of commercial (9 percent) and open space/vacant land (15 percent). The target is removal of TSS and other pollutants such as total metals, PCBs and PAHs.
4. Minor Ave/I-5 StormFilter Vault– The proposed project is a local treatment of roadway runoff from a drainage basin that discharges into the south end of Lake Union. A 680 filter cartage vault is proposed with swirl concentrators upstream for pretreatment. The basin's land use is a mix of commercial and residential. The target is the removal of TSS and associated constituents.
5. Webster Pond/Pretreatment - SPU currently owns and operates a wet pond in the upper portions of the Longfellow Creek watershed, which discharges to the creek. The pond is functional but was evaluated to determine if addition benefits could be realized thru modification. Modification of the pond was not feasible due to physical constraints (e.g. side slopes, available land, proximity to Longfellow Creek). The proposed project is to install swirl concentrators upstream of the pond to pretreat

flows prior to entering the wet pond. Pretreatment is intended to remove floatables and heavy particulates to reduce maintenance needs and extend the service life of the existing pond. Land use in the drainage basin is primarily residential. The target pollutant is TSS.

6. Blue Dog Pond/Pretreatment - SPU currently owns and operates a wet pond in the upper portions of the Diagonal MS4 drainage basin, which discharges into the Duwamish Waterway. Blue Dog pond is a detention pond located near S Massachusetts St and ML King JR Way that is functional but was evaluated to determine if addition benefits could be realized thru modification. Modification of the pond was not feasible due to physical constraints (side slopes, available land, locations of existing infrastructure). The proposed project is to install swirl concentrators upstream of the pond to provide pretreatment. The basins land use is primarily residential. The target pollutant is TSS.
7. Joint Wet Weather Treatment/ All Basins– The proposed project is to install infrastructure (e.g. pipes and pump stations) to convey stormwater to a wet weather treatment facility that King County is proposing to construct along the East Waterway of the Duwamish Waterway. SPU would pay to install the stormwater conveyance system and share costs of construction and operation of the treatment facility. Land use in the approximately 3.180 acre basin is a mix of residential, commercial and industrial. The target pollutants are TSS, metals (total and dissolved) and BEHP.
8. NDS Partnering/Piper's, Longfellow, and Thornton Creeks – The proposed project(s) would reconstruct City right-of-ways to manage flow and provide water quality treatment by use of bioretention swales (NDS). Blocks where bioretention are feasible are identified and SPU would work with community members to identify locations where there is high community acceptance.
9. SW Hinds SD/StormFilter Vault – The proposed project is to install a vault with filter cartridges in a parking lot located near Delridge Way SW and SW Spokane St. The location discharges into the West Waterway of the Duwamish Waterway. Land use in the basin is primarily roadway (60 percent) and commercial/industrial (17 percent). The target is the removal of TSS and associated pollutants.
10. South Myrtle/Shoulder Stabilization – The proposed project is to install a biofiltration swale in the City's right-of-way to reduce an existing source of solids/sediment (e.g., unpaved road shoulder) and associated pollutants, as well as provide treatment for runoff from an adjacent industrial parcel that sheet flows onto the right-of-way. The area discharges to the Duwamish Waterway and is in predominantly industrial land use. The biofiltration swale would target TSS and associated pollutants.
11. Piper's/Bioretention with flow Routing – The proposed project is to install bioretention in high priority MS4 sub-basins within the Piper's Creek Watershed. Bioretention swales would be constructed in the right-of-way. Land use in the basins is predominantly residential. The bioretention swales would target flow and stormwater volume.

12. Longfellow/Bioretention with flow Routing - The proposed project is to install bioretention in high priority MS4 sub-basins within the Longfellow Creek Watershed. Bioretention swales would be constructed in the right-of-way. Land use in the basins is predominantly residential. The bioretention swales would target flow and stormwater volume.
13. South Myrtle SD/StormFilter Vault – The proposed project is a local treatment of roadway runoff from a drainage basin that discharges to the Duwamish Waterway and is in predominantly industrial land use. A 79 –cartridge filter vault is proposed to be installed near the outfall in the City right-of-way. The target is the removal of TSS and associated pollutants
14. Minor Ave/ Cascade Filterras – This proposed project would install up to 14 Filterra stormwater treatment devices in the City's right-of-way to treat roadway runoff. The basin discharges into Lake Union. Land use is a mix of commercial and residential. The target is the removal of TSS and associated pollutants.
15. U-Village/Filterras – This proposed project would install up to 26 Filterra stormwater treatment devices in the City's right-of-way to treat roadway runoff. The basin discharges into Lake Union. The basins land use is a mix of commercial and residential. The target is the removal of TSS and associated pollutants.

SECTION 4

General Siting Elements for BMPs

During the planning of the stormwater project for the Integrated Plan, the engineers considered the following elements or traits.

High priority was assigned to elements, traits, or details that were deemed desirable:

- Must be connected to and discharge into the City of Seattle Municipal Separate Storm Sewer System (MS4)
- Construction in the City's right-of-way
- Construction on SPU-owned property
- Gravity operated
- Multiple benefits
- Meeting code requirements/code equivalent
- Sited on a vacant and available parcel or City's right of way
- Treats runoff from a subbasin with high pollutant loading potential (e.g., industrial use, known pollutant sources, source control efforts likely to be unsuccessful)
- Opportunity to leverage water quality project with other ongoing projects to reduce cost
- Can be constructed by 2025

Medium priority was assigned to elements, traits or details that were deemed acceptable:

- Sited on Seattle City Light owned property
- Sited on property with a willing seller
- Pumped operations
- Sited on school property
- Sited in a parking lot
- Sited on City of Seattle Fleets and Administrative Services Department owned property

Low priority was assigned to those attributes, elements, or traits that were not desirable:

- Sited in City of Seattle Park and Recreation Department property
- Sited on church property
- Requires adversarial condemnation
- Sited in a landfill
- Sited on Washington Department of Transportation owned property
- Sited with high ground water
- Sited where there is significant flooding
- Requires significant mitigation
- Impacted by sea level rise
- Sited on Federal property

SECTION 5

Street Sweeping Project Siting Criteria

The Street Sweeping for Water Quality (SS4WQ) Program kicked off with on-the-ground sweeping February 22, 2011. The Program cost-effectively reduces the pollutant load carried by stormwater runoff from Seattle's streets to Seattle's receiving waters.

A regenerative air sweeper sweeping the streets 2009.

Currently, street sweeping is done generally at night (18 night routes and 4 day routes) and targets arterials and industrial streets, the highest pollutant-generating roadways. This helps to minimize undesired impacts to the community and takes advantage of existing controlled parking. Under the current sweeping schedule 22 routes are swept; 20 every other week and 2 weekly covering 336 curb miles each week, of which 75 percent drain directly to our receiving waters.

The Program is a successful partnership between SPU, who sets the program direction, provides water quality expertise, and funding for the portion of routes that discharge directly to our receiving waters, and Seattle Department of Transportation (SDOT), who provides operational expertise, street sweeping services, and funding for the portion of the routes that drain to a sewage treatment plant.

Unlike construction of major structural treatment facilities, street sweeping is not constrained by site feasibility, is scalable, and can be readily implemented. Specific criteria that are considered for this Program include:

- Sweeping curbed roadways that drain directly to Seattle's receiving waters
- Using high efficiency sweepers
- Having a frequency of every one-to-two weeks
- Requiring a specified speed for the sweepers to ensure effectiveness
- Consideration of parking, currently no parking enforcement on swept streets

SECTION 6

Conventional Stormwater Treatment Siting Criteria

Probably the most common and significant fatal flaw for stormwater BMP projects is the need to construct the facility by 2025. SPU simply does not have many projects (other than those evaluated here) in the pipeline that could be designed/constructed in a short time frame. Large regional stormwater treatment facilities typically require land acquisition (often condemnation) that often need substantial environmental cleanup before work can begin and involve coordination between multiple local agencies, which results in significantly more time to plan, develop, design, and construct.. For this reason, large end-of-pipe treatment facilities were generally not considered.

Duwamish Waterway Projects

The Duwamish Waterway has been the subject of extensive source control efforts over the past 10 years due to its status as a Superfund site and ongoing efforts to cleanup sediments containing elevated levels of arsenic, polychlorinated biphenyls (PCBs), carcinogenic polynuclear aromatic hydrocarbons (PAHs), and dioxins/furans. SPU has inspected businesses and collected numerous sediment samples from the collection/conveyance system to identify and control pollutant sources in the basin. As a result, the City likely knows more about potential sources and our ability to control them in this basin than any other drainage basin in the City. Because of its Superfund status, this area is also subject to significantly more interest from the regulatory agencies, which is leading to more extensive requirements for City programs (e.g., source controls, expanded line cleaning to remove accumulations of contaminated sediment, stronger operations/maintenance efforts), as well as structural retrofits to reduce the potential for sediment in the waterway to recontaminate following cleanup.

Projects in the Duwamish Waterway were selected to capture and treat runoff from the most significant source areas where available tools/mechanisms for controlling sources are inadequate and where there is an opportunity to construct stormwater treatment facilities. To better address the water quality concerns described above, the City looked for potential opportunities to implement higher levels of treatment. Examples of target projects include:

- Subbasins where fugitive dust emissions/atmospheric deposition from local industries and vehicle emissions are affecting stormwater quality and existing regulations are insufficient to address these issues.

- Large multi-use basins that contribute a large proportion of the overall stormwater load and where given the drainage infrastructure, it will be difficult to isolate specific industrial/high pollution generating subbasins for treatment (e.g., sub-basins within the 2,600 acre Diagonal Ave S drainage basin) and where there is an opportunity to team with King County on a joint use facility.
- Major arterials in industrial/commercial areas.
- Sites where Ecology has already requested drainage/roadway improvements to reduce stormwater pollution.

A number of sites/projects were considered, but were not found to be feasible given the one or more of the following constraints:

- Projects on major arterials/transportation corridors where the remaining right-of-way has already been developed for pedestrian paths and other non-motorized use, which leaves no space to construct surface treatment systems (e.g., biofiltration and/or bioretention systems) and where high volume traffic would create significant barriers to construct and operate large underground facilities.
- Other areas with a lack of space to construct a stormwater treatment facility necessitating lengthy/expensive/politically unpopular condemnation process and/or lack of suitable site to even consider condemnation.
- Suitable site to construct a stormwater facility, but property located within WSDOT right-of-way. WSDOT is unwilling to allow any activity in its right of way that could preclude future transportation use.

Detention pond retrofit

The option of expanding/enhancing detention ponds that currently exist throughout the City was assessed; however due to constraints, retrofitting of ponds were eliminated as an Integrated Plan stormwater project option. Rationale used to evaluate existing stormwater treatment ponds are as follows:

- Pond must be currently maintained by the City
- Site constraints do not preclude retrofitting (i.e. expanding footprint and/or increasing depth)

A few existing stormwater treatment ponds in the City met the above criteria and were selected for a more detailed evaluation. The detailed evaluation resulting in the stormwater treatment ponds elimination from consideration due to the following constraints:

- Webster Pond
    - Longfellow Creek drains into and out of Webster Pond. The general criteria for the Integrated Plan are that the stormwater project must be connected, or discharge into the City's MS4. Creeks are not considered part of the City's

MS4, so Webster Pond was precluded from use as a potential stormwater project.

- Ashworth Pond
    - The topographically flat nature of the site and the upstream drainage basin would create stormwater backups into the system if the ponds depth was increased via raising of the outlet structure. This is an undesirable condition so modifications to Ashworth Pond were not considered.
- Stone Pond
    - Stormwater drainage conveyance are located far below grade of the ponds bottom making it difficult to convey additional stormwater flows into the pond with significant pipe rerouting upgradient and the hydraulic head required to fill the pond for treatment would create backups into the upstream drainage basin.
- Blue Dog Pond
    - Pond is owned by WSDOT and operated by the Seattle Parks Department; the complexity between the City and two additional departments would likely be time consuming and hinder a retrofit completion in the allowable timeframe.
    - The pond was directly next to and above the I-90 tunnel; the potential for problems associated with this proximity discouraged further consideration.

Swirl concentrators were selected as an optimal pretreatment BMP as an alternative to retrofitting existing detention ponds. The siting of these BMPs was chosen for their proximity to conveyance of a large upstream drainage basin, proximity to existing detention ponds, and for relatively few construction constraints.

SECTION 7

Creek Basin Stormwater Treatment Projects and Siting Criteria

7.1 Practices Evaluated

Stormwater treatment projects to be considered within creek watersheds were selected based upon the criteria of providing water quantity benefit in addition to achieving the water quality objectives consistent with the other basins evaluated for the integrated plan. Stormwater projects included alternatives relying on flow routing, as well as practices addressing flow directly at the source of the runoff.

7.1.1 Practices Evaluated with Flow Routing

Solutions that include routing (or capturing existing routed) flows from multiple blocks to a stormwater project location tend to maximize the cost-effectiveness of the solution. Locations with minimal alterations of the upstream and downstream conveyance system were preferred. The following practices were considered for each basin evaluated where feasible:

7.1.1.1 Roadside Bioretention with Flow Routing

Roadside bioretention with flow routing consists of constructing bioretention facilities within the planter area of the right-of-way to capture and infiltrate runoff in a shallow landscaped depression (a.k.a. Natural Drainage Systems or NDS). Where infiltration hazards do not exist and infiltration potential is considered to be high, these practices would be designed to capture the water quality event and infiltrate into native soils. Where site condition constraints exist, underdrains were assumed, either directing flow to an Underground Injection Controls or an orifice control outlet. Where space or slopes considerations were more challenging, vertical walls and/or use of weirs were assumed.

7.1.1.2 Biofilter Wetland Channel with Bioretention Elements

Biofilter wetland channels consist of sloped vegetated channel that filters runoff as it flows through the vegetation to an outlet. An example of this type of design includes the Swale on Yale project. These practices are enhanced to provide additional flow retention through storage, infiltration and evapotranspiration by adding underlying bioretention soils. Biofilter wetland channels typically include an upstream flow splitter to bypass high flows around the channel to avoid resuspension of captured pollutants and a typically smaller footprint than bioretention facilities along and therefore provide reduced flow retention. A pre-treatment

BMP such as a swirl concentrator may also be included upstream of the biofilter wetland channel.

7.1.1.3 Extended Detention Basins

Extended detention basins are a more traditional method of stormwater management intended to provide flow control through temporary storage, and to provide some water quality benefit through settling and biological processes. This BMP is expected to provide minimal volume reduction, as there is little opportunity for infiltration or evapotranspiration.

7.1.2 Practices Evaluated without flow Routing

Social and technical considerations can limit the opportunity for solutions with flow routing. Additionally addressing polluted runoff at the source allows addressing other Utility or agency goals (e.g. local conveyance and sidewalks). Project 8 on Table 1 is NDS Partnering/ Piper's, Longfellow, Thornton and was planned to maximize overlap with other agency or community goals. Project blocks would be prioritized through a community engagement process.

This alternative focused on the most cost effective of the NDS practices for right-of-way application, bioretention. Each stormwater BMP project block would be designed to provide stormwater conveyance improvements within the block and bioretention cells at the lower portion of the block to manage the runoff current reaching that block. For this analysis runoff was assumed to be the project block only; future refinement of this alternative are anticipated to reflect the increased loading when upstream drainage area is routed to the project street (for example a block that currently has a ditch and culvert system).

7.2 Basin-scale Feasibility Screening

Stormwater BMPs identified for consideration in creek watersheds, described above, were screened within each individual priority basin by developing map atlases, identifying opportunities and constraints and conducting a screening workshop.

If an alternative was only able to be sited within a low priority site as defined in Section 4, those alternatives were not put forward as prioritized projects. This was the case for all the potential extended detention pond options.

NDS approaches were all identified within high priority sites, specifically in the City's right-of-way. Opportunities for NDS were prioritized within the generally accepted technical feasibility limits of practices. Additionally sites where infiltration is restricted based generally accepted geotechnical limitations were excluded; the team acknowledges it is possible to design to restrict infiltration using liners, but this adds project cost and complexity which was not desired for the integrated plan projects. Primary NDS suitability was determined by excluding sites with the following characteristics:

- Areas Unsuitable for Infiltration (AUI). This includes the following and designates any parcel having greater than 5% AUI to be AUI for the entire parcel. The components of AUI are:
  - Steep Slopes with less than 100' uphill buffer (Slopes over 40% grade are labeled as steep slopes) from site
  - Potential for Landslides within 500' down gradient buffer (Landslides is based on known slide events from City records including those in the right of ways and private property.)
  - Confirmed and Suspected Contaminated Sites, including:
    - Leaking Underground Storage Tank (LUST) Sites
    - Other known or suspected sites/plumes
  - Landfills & Landfill Buffer of minimum of 100' from known landfills.
  - Bedrock near surface
  - Groundwater near surface
- Minimum available 'planting strip' width must be at least 10-feet (for both sides of the street added together). This was determined by calculating 'available right-of-way width', which is calculated by subtracting the required roadway width and the curb width from the total required right-of-way (ROW) width. The formula is such: Available ROW = Required ROW – (Required Roadway Width + (# of curbs * 6.5'))
  - Required Right-of-Way is specified in SDOT. Arterial Widths or the Minimum Street Right-of-Way from Figure 3.1.1b (Seattle Right-of-Way Improvements Manual).
  - Curb counts is the number of curbs for the street segment with possible values of 0, 1 or 2, and No Data receiving zero curbs. Each curb receives six feet for sidewalk and half foot for curbs.
- Street Slope is the percentage slope of the roadway segment with the optimum range for horizontal treatment systems being 0-4%, but sites with 0-7% slope were considered potentially feasible.
- Areas Mitigated by NDS: Areas already partially or fully managed by previous CIP retrofit projects were excluded from potential project sites. Although there are potential project opportunities and an ability to further improve water quality and/or water quantity objectives, a focus was placed on areas with limited or no improvements.

For NDS alternatives with flow routing, the project team also reviewed the PACT database, and using GIS and Google Earth determined available widths, sidewalks, informal drainage systems, areas of high pollutant loads (e.g. arterials), SPU priority areas, etc. to identify opportunities to locate water quality improvements to provide additional benefits with minimal infrastructure improvement costs. General considerations for alternative refinement included:

- Facilities were not located on arterials, however, ideally receive runoff routed from a nearby arterial to maximize pollutant reductions
- Streets with informal drainage systems (i.e. no curb) were preferred.

Specific considerations for Bioretention Facilities:

- Underdrain included where infiltration potential is Low or Medium.
- Potential for Underground Injection Control wells was determined from the map atlases, based on elevation in the basin relative to nearby surface water or known shallow groundwater.
- Sufficient space in right-of-way to accommodate required sizing factor for water quality.

Specific considerations for Biofilter Wetland Channel (with bioretention elements) Facilities:

- Underdrain included where infiltration potential is Low or Medium.
- Biofiltration was considered infeasible where sufficient uninterrupted longitudinal flow (i.e. presence of driveways) was unavailable

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